PB82-103664

Air Pollutants in Selected Salt Lake Basin Communities, 1971-1975

Environmental Monitoring Systems Lab.
Research Triangle Park, NC

Aug 81

U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-600/4-81-046	ORD Report	PB82 103664

4. TITLE AND SUBTITLE	5. REPORT DATE
Air Pollutants in Selected Salt Lake Basin Communities 1971-1975	August 1981
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Gary F. Evans, Peter L. Finkelstein, G. G. Akland	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
Environmental Monitoring Systems Laboratory Environmental Protection Agency Research Triangle Park, NC 27711	A03A1A
	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Same as box 9.	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

Aerometric data are reported for various air pollutants measured by the United States Environmental Protection Agency from 1971 through 1975 in four Utah communities. The communities (Kearns, Magna, Ogden, and Salt Lake City) are situated in or near the Great Salt Lake Basin in which a large copper smelter represented the largest point source of sulfur oxide emissions during the study period. Measurements were made of total suspended particulate, nitrate, sulfate, and sulfur dioxide. In addition to describing the spatial, seasonal, and long-term variations in the air quality data, the report includes discussions of related meteorology, quality assurance, and emission data.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Ambient air monitoring Total suspended particulates Suspended sulfates and nitrates Sulfur Dioxide	Salt Lake Basin Magna, Utah Copper smelter	

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
Release to Public	Unclassified	
	20. SECURITY CLASS (This page)	22. PRICE
	Unclassified	

EPA Form 2220-1 (9-73)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE

EPA 600/4-81-046
August 1981
PB82-103664

AIR POLLUTANTS IN SELECTED SALT LAKE BASIN COMMUNITIES

1971 - 1975

by

Gary F. Evans
Peter L. Finkelstein
Gerald G. Akland

Environmental Monitoring Systems Laboratory
Office of Research and Development
U. S. Environmental Protection Agency
Research Triangle Park, N.C. 27711

6-1/2"
9-1/8"
REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"
PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE
6-1/2"
9-1/8"
BEGIN LAST LINE OF TEXT
3/8"
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
PAGE NUMBER
EPA-287 (Cin.) (4-76)

DISCLAIMER

This report has been reviewed by the Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

FOREWORD

Measurement and monitoring research efforts are designed to anticipate potential environmental problems, to support regulatory actions by developing an in-depth understanding of the nature and processes that impact health and the ecology, to provide innovative means of monitoring compliance with regulations and to evaluate the effectiveness of health and environmental protection efforts through the monitoring of long-term trends. The Environmental Monitoring Systems Laboratory, Research Triangle Park, North Carolina, has the responsibility for: assessment of environmental monitoring technology and systems; implementation of agency-wide quality assurance programs for air pollution measurement systems; and supplying technical support to other groups in the Agency including the Office of Air, Noise and Radiation, the Office of Toxic Substances and the Office of Enforcement.

Four communities in the Great Salt Lake Basin (Kearns, Magna, Ogden, and Salt Lake City) were selected to represent an exposure gradient to sulfur dioxide, which was emitted primarily from a large copper smelter located near Magna, Utah. This report describes the concentrations of suspended particulates and sulfur dioxide measured from 1971 through 1975. These aerometric results will be referred to in reports of health studies of the four communities.

Thomas R. Hauser, Ph.D.
Director
Environmental Monitoring Systems Laboratory
Research Triangle Park, North Carolina

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE
6-1/2"
9-1/8"
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"
PAGE NUMBER
EPA-287 (Cin.)
(4-76)

ABSTRACT

Aerometric data are reported for various air pollutants measured by the United States Environmental Protection Agency from 1971 through 1975 in four Utah communities. The communities (Kearns, Magna, Ogden, and Salt Lake City) are situated in or near the Great Salt Lake Basin in which a large copper smelter represented the largest point source of sulfur oxide emissions during the study period. Measurements were made of total suspended particulate, nitrate, sulfate, and sulfur dioxide. In addition to describing the spatial, seasonal, and long-term variations in the air quality data, the report includes discussions of related meteorology, quality assurance, and emission data.

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

CONTENTS

Foreword iii

Abstract iv

Figures vi

Tables vii

1. Introduction 1

2. Conclusions 2

3. Area Description 3

4. Monitoring Site Locations 7

   Magna 12
   Kearns 12
   Salt Lake City 12
   Ogden 12

5. Pollutant Measurement Methods 14

   USEPA Methods 14
   USDH Methods 15

6. Air Quality Measurements 17

7. Quality Assurance Measurements 20

8. Meteorological Measurements 22

9. Emission Estimates 28

10. Results and Discussion 30

    Spatial Variation 30
    Seasonal Variation 31
    Long-term Trends 36
    Comparison of USEPA and USDH Measurements 38

References 40

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

FIGURES

Number		Page
1	Great Salt Lake Basin	4
2	Salt Lake City, UT Municipal AP Annual Wind Rose 1971	5
3	Monitoring Site Location, Magna, UT	8
4	Monitoring Site Location, Kearns, UT	9
5	Monitoring Site Location, Salt Lake City, UT	10
6	Monitoring Site Location, Ogden, UT	11
7	Salt Lake City, Ut Municipal AP Annual Wind Rose - 1972	24
8	Salt Lake City, UT Municipal AP Annual Wind Rose - 1973	25
9	Salt Lake City, UT Municipal AP Annual Wind Rose - 1974	26
10	Salt Lake City, UT Municipal AP Annual Wind Rose - 1975	27
11	Five-year Mean Concentrations by Month - Magna, UT	32
12	Five-year Mean Concentrations by Month - Kearns, UT	33
13	Five-year Mean Concentrations by Month - Salt Lake City, UT	33
14	Five-year Mean Concentrations by Month - Ogden, UT	34
15	Annual Mean Concentrations - TSP	37
16	Annual Mean Concentrations - SO_2	37
17	Annual Mean Concentrations - SO_4	37
18	Annual Mean Concentrations - NO_3	37

BEGIN LAST LINE OF TEXT HERE
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

TABLES

Number		Page
1	Summary of USEPA Monitoring Site Changes	13
2	Comparison of USEPA and USDH Sampling Methods, Times, and Frequencies	16
3	Monthly Mean Concentrations for 1971-1975, Magna, UT	18
4	Monthly Mean Concentrations for 1971-1975, Kearns, UT	18
5	Monthly Mean Concentrations for 1971-1975, Salt Lake City, UT	19
6	Monthly Mean Concentrations for 1971-1975, Ogden, UT	19
7	Rockwell Audit Results, November 11 - December 28, 1974	21
8	Frequency and Duration of Air Stagnation Episodes, 1965-1975	23
9	Utah Emission Estimates (tone/year)	29
10	Summary of Five-year Mean Concentrations, $\mu g/m^3$	30
11	Annual Maximum Concentrations, $\mu g/m^3$	35
12	Percentage Change in Concentration 1973-1975 Average vs 1971-1973 Average	36
13	Spearman Rank Correlation Coefficients Daniel's Test for Trend	38
14	Comparison of Data from USEPA and USDH	39

BEGIN LAST LINE OF TEXT HERE
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

SECTION 1

INTRODUCTION

The Community Health and Environmental Surveillance System (CHESS) was a program conducted by the Environmental Protection Agency to study the relationships between health parameters and air pollutants in various regions of the United States. Often epidemiological studies investigating a pollutant, such as sulfur dioxide, are blurred by the presence of other pollutants. However, the Great Salt Lake Basin offers a unique setting for observing health effects of sulfur dioxide because the concentrations of other pollutants are generally low. Four communities in the Great Salt Lake Basin (Magna, Kearns, Salt Lake City, and Ogden) were chosen to represent the exposure gradient to sulfur dioxide, which was emitted primarily from a large copper smelter located near Magna, Utah.

The concentrations of sulfur dioxide (SO_2) and other pollutants measured through 1971 in the four Utah communities have been published.* The purpose of this report is to describe the concentration levels of SO_2 and suspended particulates for 1971 through 1975. These aerometric results will be referred to in reports of health studies of the four communities. Complete data listings since 1971 are available from EPA's National Aerometric Data Bank (NADB).

*The matter of misinterpretation or overinterpretation of data or results of analyses of data collected as part of the CHESS Program contributed to considerable controversy regarding the validity and accuracy of results of early CHESS studies, as interpreted and reported in a 1974 EPA monograph.[1] The controversy eventually led to the 1974 "CHESS Monograph" becoming the subject of U.S. Congressional oversight hearings in 1976. Subcommittees of the U.S. House of Representatives Committee on Science and Technology produced a report on the Monograph, other aspects of the CHESS Program, and EPA's air pollution research programs generally - a report entitled "The Environmental Protection Agency's Research Program with Primary Emphasis on the Community Health and Surveillance System (CHESS): An Investigative Report." That report, widely referred to as either the "Brown Committee Report" or the "Investigative Report" (IR), contained various comments regarding sources of error in CHESS Program air quality and health effects data and quality control problems associated with such data collection and analysis.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE

SECTION 2

CONCLUSIONS

- Of the four study communities, Magna and Kearns were most impacted by the smelter because of both proximity and frequency of impacting wind directions.
- Five-year (1971-1975) mean concentrations of SO_2 and $SO_4^=$ decrease with increasing distance from the smelter.
- Marked seasonality is observed in the concentrations of all pollutants with winter measurements exceeding summer measurements.
- Annual maximum pollutant concentrations tended to occur during winter periods of atmospheric stagnation which often impacted the entire study area.
- The most notable trend was a monotonically increasing concentration of SO_2 observed in Magna over the five-year study period. Other statistically significant trends included an increase in SO_2 at Kearns, an increase in $SO_4^=$ at Magna and decreased concentrations of TSP at both Salt Lake City and Ogden.

6-1/2"
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

SECTION 3

AREA DESCRIPTION

The Utah study area is situated in the north central part of the state and includes Ogden, Salt Lake City, Kearns, and Magna (Figure 1). These communities were selected on the basis of the availability of meteorological information, emissions inventories, and previous air quality measurements to provide an exposure gradient for sulfur dioxide.

Except for Ogden, the study areas are located on the floor of the Salt Lake Valley, 1300 m above mean sea level. Great Salt Lake lies to the northwest of the communities in the valley. The nearest point of the lake is approximately 19 km from Salt Lake City. The ridges of the Wasatch Mountains and the Oquirrh range rise to heights of 3,400 m and 3,000 m above mean sea level, respectively, and present a formidable barrier to east-west movement of air masses.

Because of the topographic features of the area, local climatology plays an important role in air pollution considerations. In particular, wind flow southeast of the copper smelter is influenced by the proximity of the Salt Lake Valley to the canyons on the west slopes of the Wasatch Mountains. Differential heating by the sun results in upslope winds in the afternoon and evening and downslope winds at night and in the morning.

An inspection of the wind rose for the Salt Lake City Airport, which is typical of the three communities in the Salt Lake Valley, reveals that during 1971 (Figure 2) approximately 50% of the winds were from the south to east-southeast, 30% were from north to west-northwest, and the remaining 20% were calm and spread over other directions. Winds from the south to east-southeast represent nighttime downslope winds, which usually persist for approximately 15 hours each day from 9 p.m. to 12 noon, and result from cool air flowing down the Salt Lake Valley slopes to the south and the Wasatch canyons, to the east and southeast of Salt Lake City. With sunlight heating the mountain slopes, an up-valley flow (WNW-N) starts approximately at noon and continues throughout the afternoon and evening. Mean velocity of the up-valley winds is approximately 4 mps, and that of the down-valley winds is approximately 3 mps.

A mountain valley wind pattern such as this has important implications for the long-term air pollution situation in the Salt Lake Valley. Pollutant sources to the north and northwest or those to the south and southeast would affect the cities of Salt Lake City (pop. 175,000), Magna (pop. 6,000), and Kearns (pop. 17,000) approximately 75 percent of the time. Magna and Kearns are located approximately 8 and 13 km, respectively, southeast from the smelter and are downwind approximately 30 percent of the time. Therefore,

BEGIN LAST LINE OF TEXT HERE
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

EPA-287 (Cin.)
(4-76)

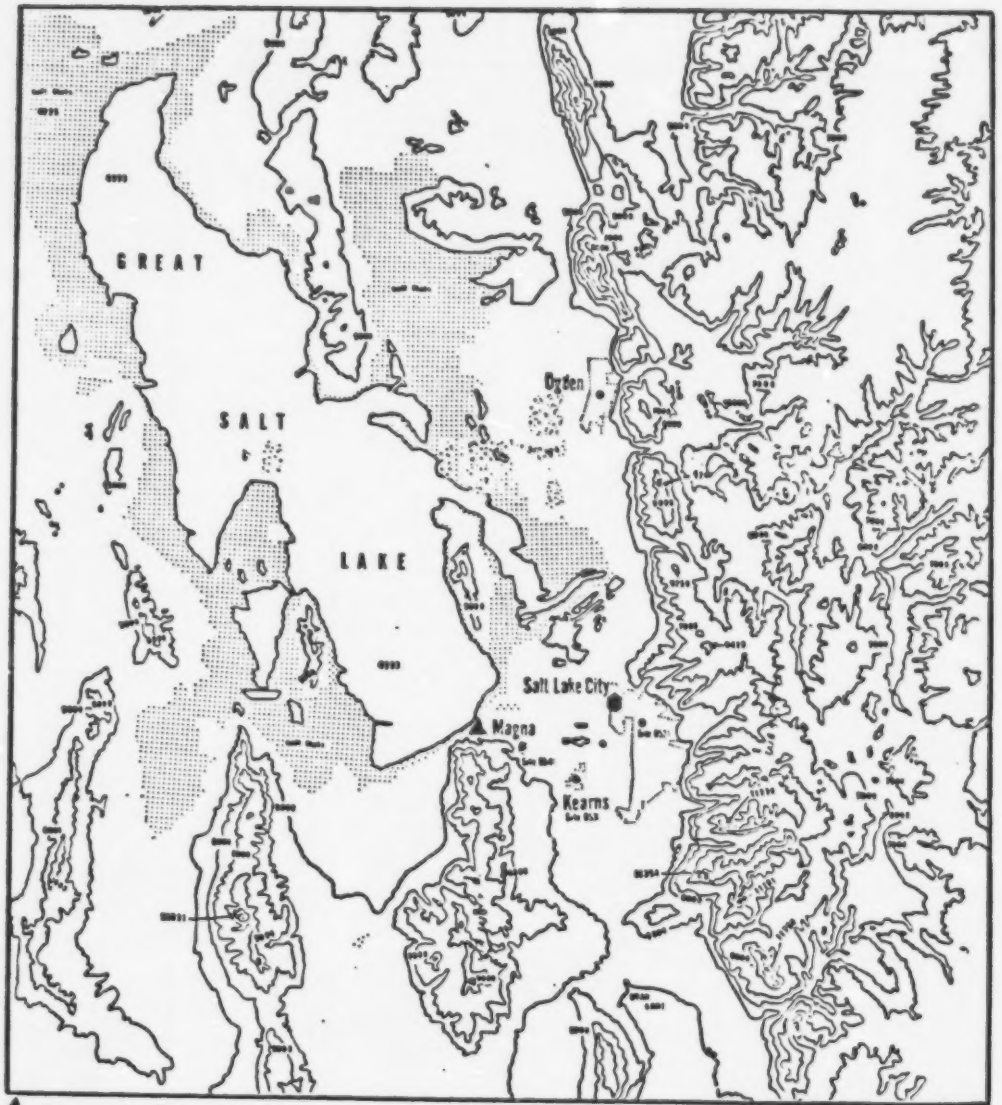

Figure 1. Great Salt Lake Basin

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

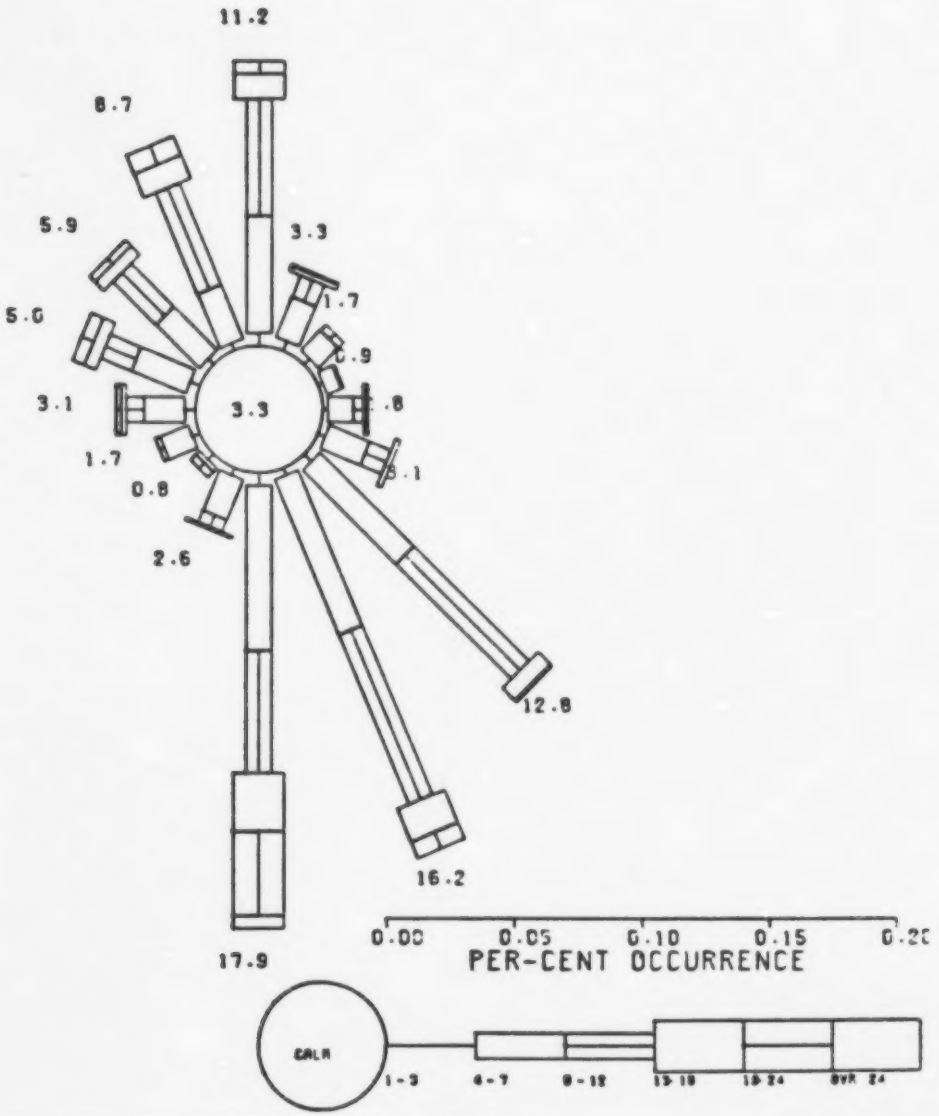

Figure 2. Salt Lake City, Utah, Municipal AP Annual Wind Rose 1971

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

pollution from the smelter can be expected over Magna and Kearns from noon to evening. However, Salt Lake City, which is 21 km due east of the smelter, is seldom directly affected by pollutants from the smelter.

The fourth study site, Ogden (pop. 70,000), lies out of the Salt Lake Valley 56 km due north of Salt Lake City in the foothills of the Wasatch Mountains. Inspection of summarized wind data for Hill Air Force Base near Ogden reveals a pattern different from that of the other three cities. Downslope winds out of Weber Canyon and other large canyons to the east result in prevailing easterly winds from the Wasatch Mountains; however, a southerly flow that might carry sulfur dioxide emissions from the smelter is also evident.

One factor affecting air pollution potential is atmospheric stability. Climatological data from the radiosonde station at Salt Lake City Airport rank this region as one of the highest in the nation for total hours of inversion (stable) conditions and also for total number of days during which inversion occurs. Inversions are observed on approximately 80% of the mornings throughout the year. Summer morning inversions occur with a frequency of 90 to 95%. Although winter morning inversions average only 75 to 80%, they tend to persist during the day, particularly when the wind speed is less than 2 mps. In warmer months, rapid heating tends to dissipate the more frequent morning inversions. Another indicator of high air pollution potential is average windspeeds aloft of less than 4 mps through the urban mixing depth. Salt Lake City frequently averages less than that, particularly in the fall and winter months.

SECTION 4

MONITORING SITE LOCATIONS

The air monitoring protocol employed in the program for monitoring human exposure to environmental pollutants has been described elsewhere[2,3]. For the Utah study communities, the air monitoring sites were located within 2.5 km of the center of the human population under surveillance. These air monitoring sites were located to represent the air quality exposure of the respective study populations in residential neighborhoods. Sulfur dioxide, total suspended particulate, suspended sulfate, and suspended nitrate concentrations were measured from December 1970 to September 1976. Data on sulfur dioxide and total suspended particulate concentrations in these communities were also available from the Utah State Department of Health (USDH) which monitored independently during this period.

For convenience, prior to July 1972, EPA pollutant monitors were placed at the same sites utilized by te USDH. All of these sites were located on the rooftops of buildings. Since the EPA was interested in human health effects, it appeared that these measurements should be made near ground level closer to the breathing height. Therefore, sites were moved in 1972 to locations chosen according to guidelines established by the EPA Health Effects Research Laboratory at that time.

These guidelines for locating sites were as follows:

a. A site shall be located as closely as possible to the geographic center of a sector where the population under surveillance resides.

b. In locating a site, special consideration shall be given to avoid local effects from biasing sources, (i.e., point sources such as industrial stacks or chemical exhausts, and general sources such as heavy traffic streets, intersections, and freeways).

c. A station shall be positioned and oriented to receive minimum effects of local wind disturbances caused by trees, tall buildings, and terrain, and the inlet probe shall be positioned clear of any obstruction to air flow 45° or more around the station and shall be 3.0 ± 1.0 m above ground.

The site locations utilized by EPA are described below and are shown in Figures 3-6. These sites were purposely located in close proximity to the population under study and therefore represent average exposure of the neighborhoods.

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE

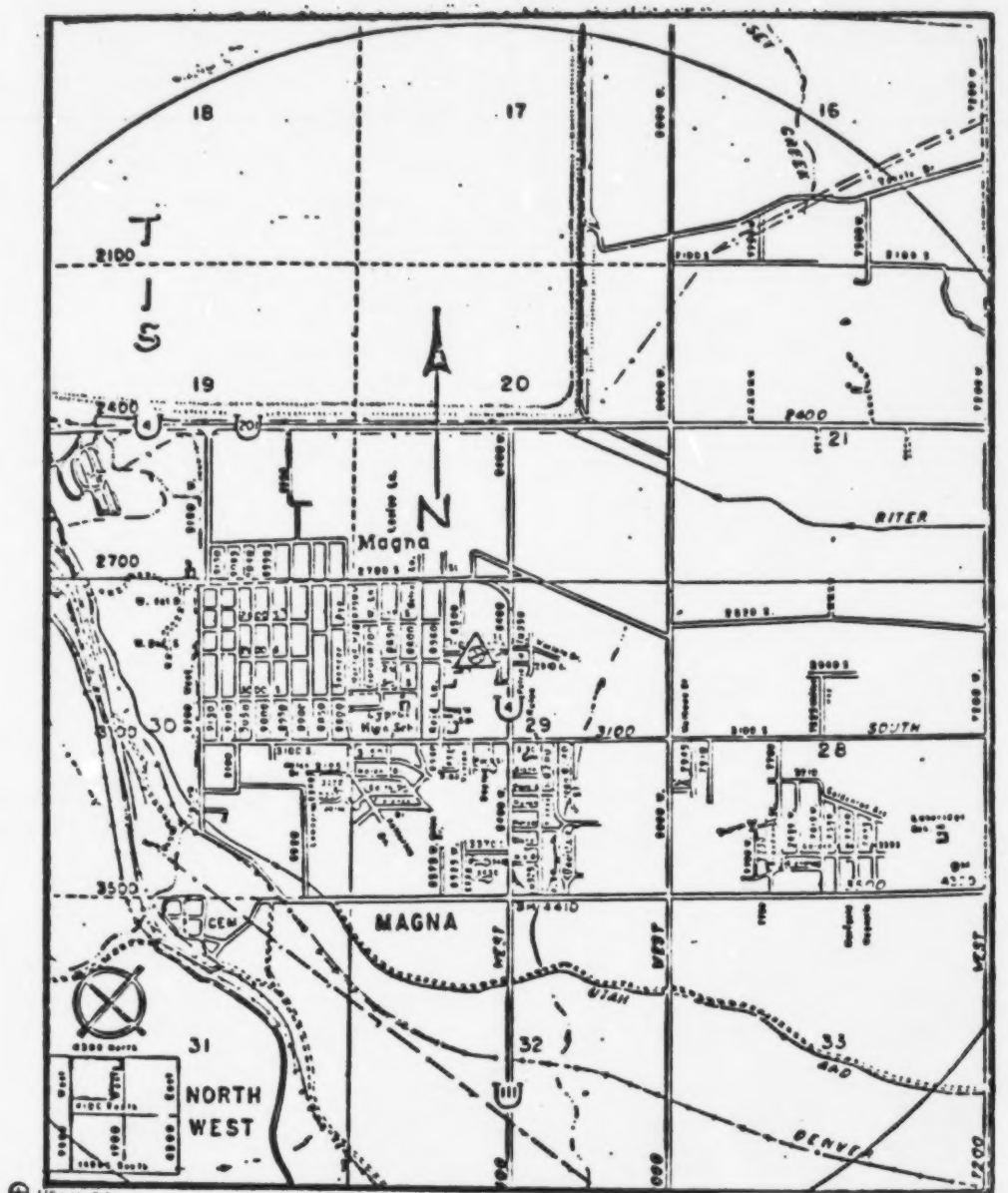

Figure 3. Monitoring Site Location
Magna, Utah
8560 W. 29355 South Street

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

Figure 4. Monitoring Site Location
Kearns, Utah
Kearns Junior High School
4040 W. 5305 South Street

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

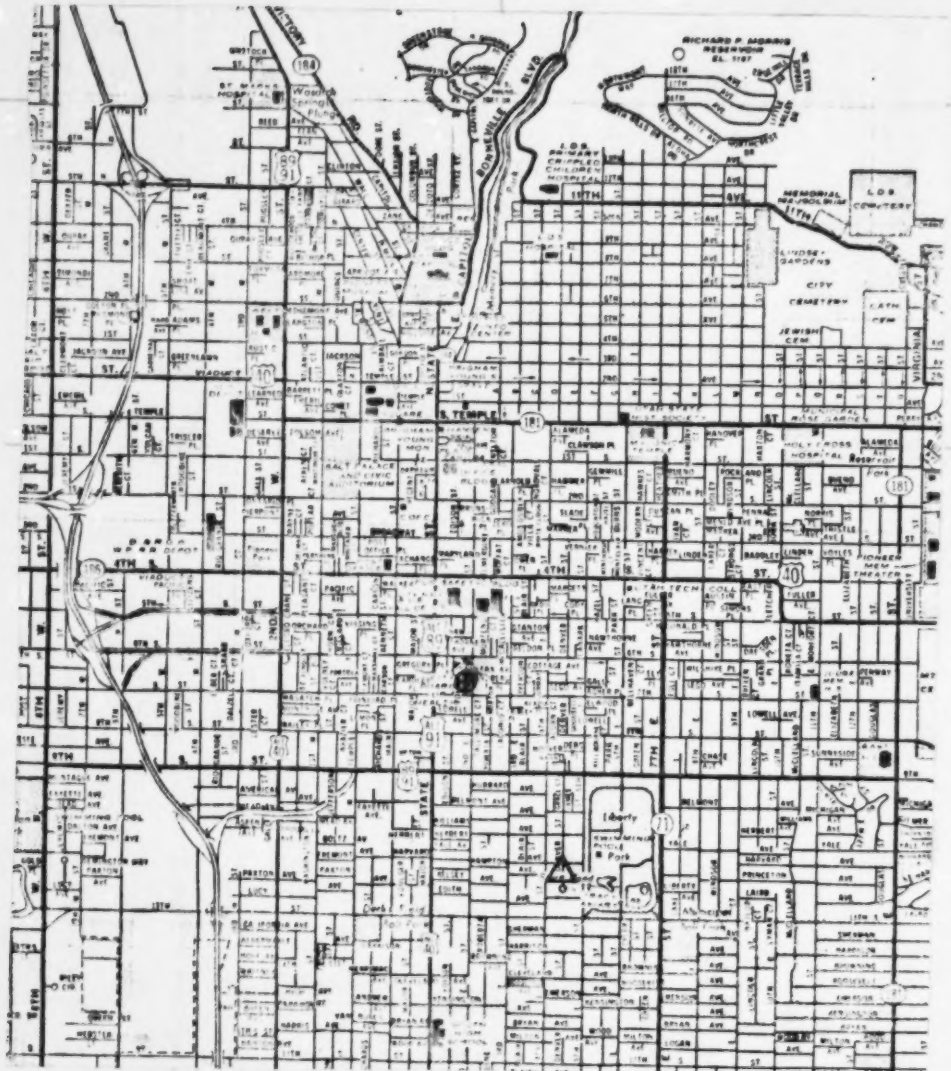

Figure 5. Monitoring Site Location
Salt Lake City, Utah
Denver Circle

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

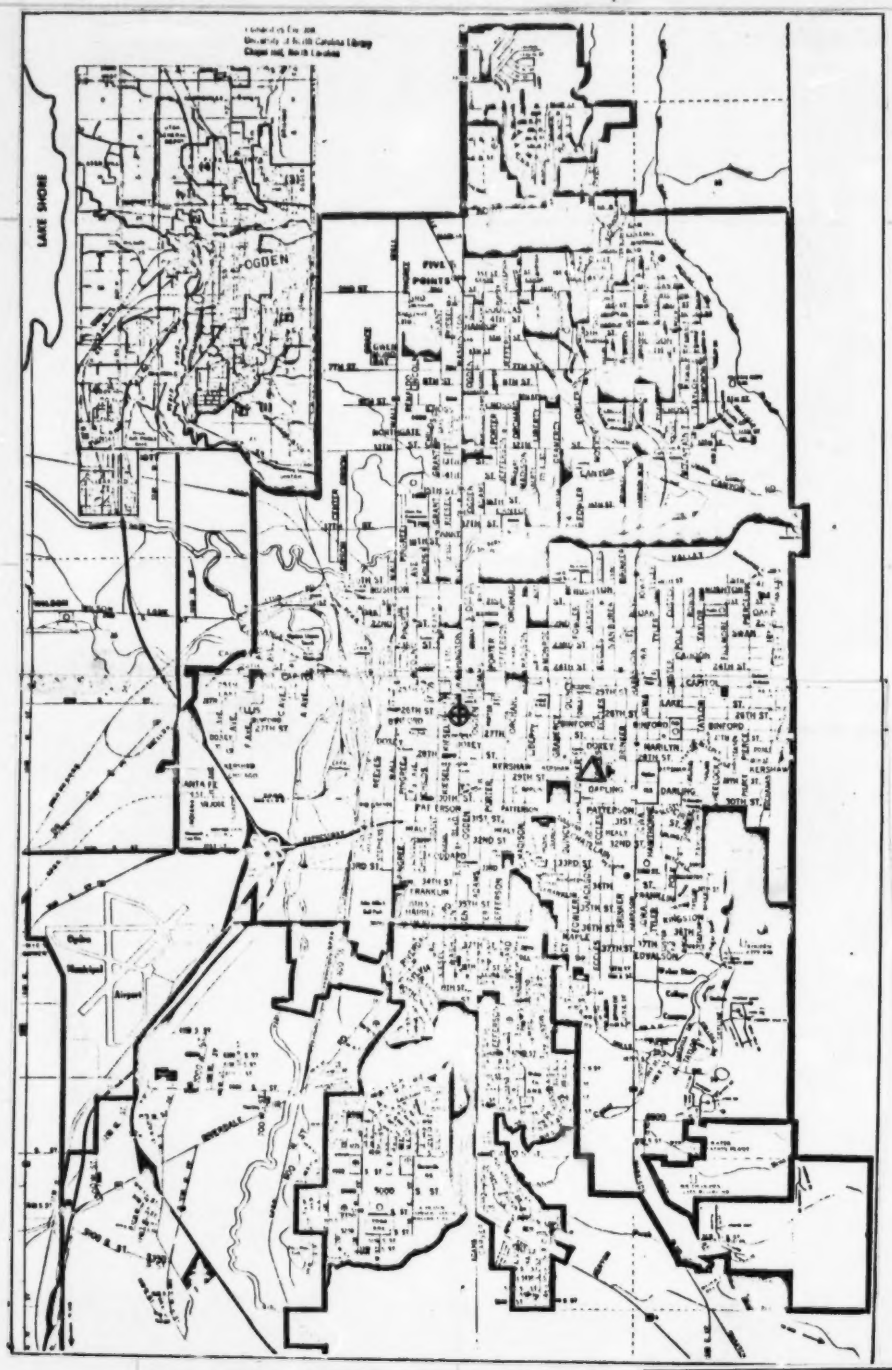

Figure 6. Monitoring Site Location
Ogden, Utah
Mid-Block Park
Van Buren and 28th Street

Reproduced from best available copy.
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

Magna - The air monitoring apparatus in Magna was located on the roof of the Brockbank Junior High School from December 1970 until September 1972. At that time, the sensors were moved approximately 90 m across the school playground to a ground level location. The school is one-story with a roof about 6 m above ground. There are no tall trees or other obstructions to airflow within several hundred meters of the school complex. The school is located in the residential neighborhood. A moderately busy thoroughfare is located two blocks south of the school, too far to cause a bias from northerly winds from the smelter (See Figure 3).

Kearns - During the same period, December 1970 through September 1972, the air monitoring apparatus for the Kearns community was located on the roof of the Kearns Junior High School, a one story building except for the auditorium, which extends slightly higher. The air monitoring equipment was located at the one-story height approximately 6 m above ground. This site was moved during September 1972 to a ground level location approximately 180 m across the school playground. The school is located in a residential neighborhood with no busy thoroughfares nearby (See Figure 4).

Salt Lake City - During the period December 1970 through July 1972 in Salt Lake City, the air monitoring apparatus was on top of the two-story City-County Health Complex approximately 11 m above ground. To the north and east of the building are relatively busy commercial streets. Parking lots are located to the south and west of the building. The buildings near the Health Complex are one story, and no tall trees are present. The site was moved to ground level during July 1972, to a location approximately 1.5 km southeast in a quiet residential neighborhood, on the perimeter of a cul-de-sac (see Figure 5).

Ogden - During the same period, air monitoring apparatus in Ogden was located on the roof of the one-story City-County Health Department. The roof is approximately 5 m above ground. A 15 m tall tree is located approximately 12 m east of the building, and a fire department building also to the east of the building has a smoke stack approximately 15 m high and approximately 60 m from the monitoring equipment. The stack emits flue gas from the gas-fired boiler in the fire department. The streets on two sides of the building are busy commercial thoroughfares. The site was moved in July 1972, to a ground level location approximately 1.5 km east of the Health Department building (See Figure 6).

A summary of these changes is given in Table 1.

BEGIN LAST LINE OF TEXT HERE
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

EPA-287 (Cin.)
(4-76)

TABLE 1. SUMMARY OF USEPA MONITORING SITE CHANGES

Community	Original Location	Dates	New Location	Dates
MAGNA	Brockbank Jr Hi School 2935 S. 8560 W Elevation above ground - 6 m Elevation above MSL - 1320 m	12/70-9/72	Brockbank Jr Hi Sch 2935 S. 8560 W (90 m from original) 1.5 m 1315 m	10/72 - cont.
KEARNS	Kearns JHS 4040 W. 5305 S. Elevation above ground - 6 m Elevation above MSL - 1385 m	10/70-9/72	Kearns JHS 4040 W. 5305 S. (180 m from original) 1.5 m 1380 m	10/72 - cont.
SALT LAKE CITY	City/County Health Dept. 610 S. 2E Elevation above ground - 10.5 m Elevation above MSL - 1305 m	10/70-7/72	Residential area 11 St. and Denver (1.5 km SE of original) 1.5 m 1305 m	8/72 - cont.
OGDEN	Weber Co H.D. 2370 Grant Ave. Elevation above ground - 4.5 m Elevation above MSL - 1320 m	12/70-7/72	Mid Lot Park 23 St & Eccles (1.5 km E of original) 1.5 m 1365 m	8/72 - present

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

SECTION 5

POLLUTANT MEASUREMENT METHODS

The methods used by the EPA and the USDH to monitor for pollutants are briefly discussed below. Detailed descriptions of the methods used by EPA are USEPA methods presented in Reference 1.

USEPA METHODS

Sulfur Dioxide

The 24-hour sulfur dioxide gas bubbler system was used to monitor for sulfur dioxide. From an ambient air inlet, air is drawn through a 15 cm long bubbler stem of 6-mm tubing. The tubing is drawn to an inner tip diameter of 0.635 mm to control bubble size. The air then bubbles through 50 ml of a 0.1-M potassium tetrachloromercurate (TCM) solution contained in a 164- by 32-mm polypropylene tube. Exhaust air passes through a glass wool moisture trap. The air then passes through a 27-gauge hypodermic needle used as a critical orifice to control the flow rate at 0.18 to 0.20 liter/min. A second moisture trap is placed between the needle and the vacuum source to reduce corrosion of both the vacuum pump and the needle. The traps also provide a container for overlow of TCM solution if the train is assembled incorrectly. Flow rate is measured at the beginning and end of each sample period. Chemical analysis is performed using the modified West-Gaeke procedure.[4,6] Results are reported in micrograms per cubic meter ($\mu g/m^3$).

Total Suspended Particulate

The high-volume air sampler is used to collect fairly large quantities of particulate matter on filters. The sampler passes ambient air through a 20- by 25-cm glass fiber filter at a starting flow rate of approximately 1.7 m^3/min. The flow rate is sufficiently large to allow collection of suspended particulates between 0.1 and 30 μm in diameter. The sampler and rotameter are routinely calibrated as a unit for accurate flow rate determinations. Furthermore, each unit is routinely inspected and repaired every 25 calendar days. A shelter of standard design protects the sampler from adverse weather conditions and vandalism. The total weight of particulate matter collected on each filter is determined gravimetrically following the Environmental Protection Agency standard reference method.[7,8]

Nitrate Ion

Analysis was performed with an autoanalyzer on an aqueous extract of a section of the particulate filter (about 10 percent). The filter section was washed twice to obtain the final volume of 50 ml. Analysis of the

BEGIN LAST LINE OF TEXT HERE
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

extract consisted of reduction of the nitrate to nitrite by a copperized-cadmium reduction column. The nitrite is reacted with sulfanilamide in acidic solution to form a diazo compound. This compound then couples with N-1-Naphthylenediamine dihydrochloride to to form a reddish-purple azo dye which is determined colorimetrically at a wavelength of 520-540 nanometers.

Sulfate Ion

Analysis of the extract is by the methylthymol blue (MTB) method. The MTB method is based on the spectral differences that exist in basic solutions (pH 12.5-13.0) between the barium complex of MTB and the free MTB. At this pH the barium complex is blue and free MTB is brownish-red. The amount of free MTB, monitored colorimetrically at wave lengths of 460-480 nanometers, is the measure of the amount of sulfate.

USDH METHODS

Sulfur Dioxide

Sulfur dioxide is measured continuously using the automatic conductivity method with hydrogen peroxide as the absorbing solution.[9] Other gases present in ambient air may be expected to interfere with this method. Half-hour averages are available for 1971-73 and hourly averages from 1974-75.

Total Suspended Particulate Matter

Particulates were collected by a high-volume sampler of special design that is significantly different from the one defined in the Federal Register. The sampler shelter is bigger than the regular shelter so that more space is available between the filter holder and the edges of the shelter. An induction motor is used to pull the sample through and a calibrated (with a Roots meter) magnehelic pressure transducer is used to measure air flow through the sampler. The roof of the shelter is flat. Taped on the under side of the lid was a calibration table converting transducer reading to flow.

Because the design of this sampler is different from that described in the Reference Method, it is highly probable that the data collected with this sampler is not comparable to data collected using a standard sampler. It is expected that the particle size cut-off for the two samplers would be different.

In addition to differences in shelter design, samples are conditioned at 50°C before weighing. This conditioning is likely to result in loss of the volatile organic matter.

Table 2 compares the measurement methods, sampling times, and sampling frequencies used by EPA and the USDH. The EPA measurements were taken daily on a 24-hour integrated basis beginning sometime between 8 a.m. and 12 noon. The USDH daily measurements were made from midnight-to-midnight. The USDH filters were weighed in Utah while the EPA filters were mailed to Research Triangle Park, N.C. for weighing.

BEGIN LAST LINE OF TEXT HERE
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cln.) (4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

TABLE 2. COMPARISON OF USEPA AND USDH SAMPLING METHODS, TIMES, AND FREQUENCIES

Measurement by	Pollutant	Method	Sampling Frequency	Sampling Time
USEPA	Sulfur dioxide	Bubbler (24-h sample: West-Gaeke analysis)	Daily	24 h
	Total suspended particulate	High-volume sampler	Daily	24 h
Utah State	Sulfur dioxide	Automatic conductivity	Continuous	1/2 h (1970-73) 1 h (1974-76)
	Total suspended particulate	High-volume sampler	Daily	24 h

6-1/2"
9-1/8"
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

SECTION 6

AIR QUALITY MEASUREMENTS

As discussed previously, ambient air quality was monitored by EPA in the North Central Utah communities of Kearns, Magna, Ogden, and Salt Lake City from December 1970 through September 1976. Twenty-four-hour integrated measurements of total suspended particulate (TSP), sulfur dioxide (SO_2), suspended sulfate (SO_4), and nitrate (NO_3) were made on a daily basis in each of the four communities.

Monthly averages for the EPA data are shown by site in Tables 3 through 6. Geometric means were computed for TSP data to conform with the Ambient Air Quality Standard. Arithmetic means were employed for the other three pollutants. Because of the pronounced seasonality in the data, only years with complete data coverage (i.e., 1971-1975) are considered in this report for the purpose of interpreting trends. An analysis and discussion of these and related data appear in Section 10.

BEGIN LAST LINE OF TEXT
3/8"
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS

EPA-287 (Cin.)
(4-76)

TABLE 3. MONTHLY MEAN CONCENTRATION FOR 1971-1975, $\mu g/m^3$, MAGNA, UTAH

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Mean
						TSP*							
1971	59	60	71	51	42	49	42	59	59	52	68	54	54
1972	78	94	92	75	74	53	64	77	59	40	38	79	65
1973	139	100	52	58	64	67	76	81	80	100	51	98	77
1974	82	105	86	59	95	63	75	74	88	61	80	98	79
1975	133	65	36	42	45	44	57	51	57	56	96	157	63
Mean	93	83	64	56	61	55	61	68	67	59	63	92	67
						$SO_4^=$							
1971	19.4	12.1	13.4	7.6	10.0	9.9	4.2	13.0	9.7	15.3	20.5	14.9	12.5
1972	17.3	17.6	13.7	13.6	6.4	7.0	6.0	11.0	8.5	10.6	13.5	30.0	12.8
1973	48.4	26.9	12.8	9.1	7.9	10.1	12.3	9.7	15.1	17.3	10.5	21.4	16.8
1974	14.9	19.7	8.0	6.9	8.9	6.8	9.9	10.0	13.9	19.3	19.2	23.8	13.6
1975	53.8	10.9	5.3	5.8	7.5	6.7	6.2	6.6	8.8	11.9	16.7	24.7	13.7
Mean	30.8	17.4	10.6	8.6	8.1	8.1	7.7	10.1	11.2	14.9	16.1	23.0	13.9
						SO_2							
1971	87	65	35	93	89	49	5	20	31	69	110	97	62
1972	143	133	100	54	33	38	34	42	61	85	114	213	86
1973	282	235	91	81	77	55	58	66	119	86	75	304	117
1974	181	181	69	105	128	35	70	59	164	261	291	232	143
1975	387	159	61	53	85	43	25	31	104	168	329	346	149
Mean	216	155	71	77	82	44	38	44	96	134	184	238	111
						NO_3^-							
1971	2.93	1.33	0.49	0.70	1.14	1.75	1.90	1.65	1.57	1.90	4.20	3.30	1.96
1972	4.91	7.01	0.93	0.89	0.85	0.78	0.94	1.00	0.89	0.57	0.34	0.96	1.67
1973	2.01	1.80	0.55	0.27	0.32	0.60	0.48	0.54	0.63	1.01	0.81	1.73	0.89
1974	1.83	4.39	0.69	0.58	0.72	0.53	0.90	0.72	0.75	0.72	1.02	1.84	1.24
1975	11.18	3.17	1.05	1.12	0.86	0.84	1.67	1.37	1.48	1.70	3.41	5.87	2.81
Mean	4.57	3.54	0.74	0.71	0.78	0.90	1.18	1.06	1.06	1.18	1.96	2.74	1.70

*Geometric Mean

TABLE 4. MONTHLY MEAN CONCENTRATIONS FOR 1971-1975, $\mu g/m^3$, KEARNS, UTAH

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Mean
						TSP*							
1971	32	43	33	42	35	42	44	44	41	38	41	34	39
1972	53	54	50	51	65	57	61	61	49	33	31	47	50
1973	72	55	39	41	49	59	62	66	50	53	30	47	51
1974	35	57	44	45	60	59	53	66	68	49	37	47	50
1975	55	35	24	34	34	38	57	53	57	49	60	56	44
Mean	47	48	37	42	47	50	55	57	52	44	39	46	47
						$SO_4^=$							
1971	9.4	8.2	5.8	4.9	5.7	5.7	4.4	7.3	6.5	10.8	13.9	11.6	7.9
1972	9.6	11.5	6.4	8.6	4.7	4.8	4.9	6.1	5.1	8.2	6.8	25.2	8.2
1973	33.8	16.7	8.1	5.3	6.1	4.6	6.8	4.9	8.6	9.0	3.1	10.1	9.9
1974	11.1	7.2	5.3	5.4	4.0	4.6	3.9	5.3	6.9	11.4	6.3	9.9	6.8
1975	16.0	6.0	3.4	4.4	4.3	4.4	3.7	4.7	5.2	5.5	9.9	12.9	6.7
Mean	16.0	9.9	5.8	5.7	5.0	4.8	4.7	5.7	6.5	9.0	8.0	13.9	7.9
						SO_2							
1971	31	21	14	16	29	14	5	18	15	36	37	34	23
1972	35	47	25	23	12	8	9	16	19	34	41	84	28
1973	146	96	32	21	21	20	14	11	38	79	28	70	45
1974	50	65	31	24	40	9	8	8	49	71	78	60	39
1975	114	43	22	29	18	18	8	10	21	35	126	89	44
Mean	75	54	25	23	24	14	9	13	28	51	62	67	36
						NO_3^-							
1971	2.11	1.76	0.84	1.10	1.52	2.23	2.45	2.03	1.74	2.66	4.72	5.52	2.42
1972	6.25	7.49	0.97	1.10	1.25	1.04	1.18	1.26	1.21	0.89	0.91	1.41	2.04
1973	1.98	2.67	1.24	0.60	0.81	0.59	0.78	1.12	0.84	1.18	0.73	1.86	1.20
1974	1.72	3.08	1.00	1.05	0.78	0.73	1.06	0.94	1.16	1.84	2.00	3.42	1.56
1975	8.44	4.27	1.40	1.77	1.39	1.33	2.08	2.08	2.06	2.00	4.38	5.65	3.07
Mean	4.10	3.85	1.09	1.12	1.15	1.18	1.51	1.49	1.40	1.71	2.55	3.57	2.06

*Geometric Mean

TABLE 5. MONTHLY MEAN CONCENTRATIONS FOR 1971-1975, $\mu g/m^3$, SALT LAKE CITY, UTAH

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Mean
						TSP*							
1971	90	80	80	63	52	63	67	65	63	66	100	76	71
1972	126	148	101	90	87	75	80	79	74	52	55	102	86
1973	112	111	61	51	52	64	67	67	49	70	66	79	68
1974	90	101	68	54	77	72	60	68	78	57	60	63	70
1975	79	52	42	40	41	44	50	44	40	46	57	89	50
Mean	98	93	68	57	59	63	64	63	59	58	66	81	68
						$SO_4^=$							
1971	10.4	6.4	4.6	4.2	5.3	5.6	4.6	6.0	5.6	10.2	12.5	11.4	7.3
1972	14.2	10.0	6.8	10.0	4.9	5.8	5.2	6.2	4.2	4.7	3.8	20.6	8.0
1973	28.8	19.7	5.4	5.1	2.8	4.7	6.2	3.9	7.2	5.3	4.2	8.5	8.4
1974	9.6	5.8	4.2	3.8	4.1	4.1	2.9	3.8	4.3	6.8	4.3	6.8	5.2
1975	12.4	5.0	3.0	3.3	3.2	3.1	3.3	3.5	3.3	4.2	7.6	12.9	5.4
Mean	15.1	9.4	4.8	5.3	4.1	4.7	4.4	4.7	4.9	6.2	6.5	12.0	6.9
						SO_2							
1971	18	18	9	17	16	14	8	11	10	19	26	17	15
1972	23	34	14	11	12	9	11	11	12	13	13	57	18
1973	105	53	16	14	13	17	8	9	19	29	17	26	27
1974	23	23	10	10	15	5	6	7	9	10	10	17	12
1975	31	17	6	7	9	8	5	7	8	12	43	52	17
Mean	40	29	11	12	13	11	8	9	12	17	22	34	18
						NO_3^-							
1971	3.96	2.60	1.32	1.28	2.11	3.38	3.16	3.08	2.30	3.58	6.76	5.95	3.29
1972	9.17	7.12	1.73	1.79	1.45	1.31	1.35	1.11	1.35	1.08	1.44	3.55	2.68
1973	4.23	5.57	1.80	1.05	0.55	0.63	0.79	1.03	0.83	1.23	1.52	2.74	1.80
1974	3.84	3.87	1.39	1.07	1.10	0.93	1.24	1.19	1.55	2.89	2.93	4.90	2.32
1975	8.91	4.64	1.95	1.78	1.59	1.55	2.21	1.84	1.58	1.95	4.39	6.91	3.28
Mean	6.02	4.76	1.64	1.39	1.36	1.56	1.75	1.65	1.52	2.15	3.41	4.81	2.67

*Geometric Mean

TABLE 6. MONTHLY MEAN CONCENTRATIONS FOR 1971-1975, $\mu g/m^3$, OGDEN, UTAH

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Mean
						TSP*							
1971	80	86	61	63	48	58	65	73	64	71	89	59	66
1972	103	136	94	86	88	72	71	53	46	44	45	149	77
1973	131	116	59	37	45	52	43	57	38	45	44	63	56
1974	47	71	43	42	52	45	51	50	62	36	40	42	47
1975	73	40	29	29	30	33	43	45	49	43	49	76	43
Mean	82	83	53	48	49	50	53	55	51	47	51	71	56
						$SO_4^=$							
1971	8.2	4.8	3.3	3.4	3.9	3.7	4.6	6.2	5.1	5.6	8.8	9.0	5.6
1972	9.8	8.7	5.0	5.7	4.7	4.7	4.2	4.6	2.9	3.1	3.7	11.4	5.8
1973	15.6	10.2	4.2	2.7	4.7	2.6	4.4	3.6	8.3	3.0	4.1	3.7	5.7
1974	4.8	3.2	3.4	3.7	2.2	2.6	2.7	2.8	3.0	3.6	3.8	4.1	3.4
1975	12.1	3.3	2.4	2.7	2.6	2.6	3.1	3.3	3.3	3.5	4.9	7.4	4.3
Mean	10.1	6.0	3.7	3.6	3.6	3.2	3.8	4.1	4.5	3.8	5.1	7.1	5.0
						SO_2							
1971	13	9	5	11	10	7	5	7	7	9	14	15	9
1972	17	15	11	7	7	6	10	7	8	8	16	33	12
1973	36	17	8	7	6	15	7	7	7	16	13	25	13
1974	28	11	8	9	11	5	5	5	7	10	9	10	10
1975	60	13	6	7	9	7	5	5	5	6	9	14	12
Mean	31	13	8	8	9	8	6	6	7	10	12	19	11
						NO_3^-							
1971	3.43	1.89	1.20	1.25	1.43	2.28	2.55	2.76	2.48	3.64	5.58	4.52	2.72
1972	5.02	7.29	1.51	1.43	1.35	1.40	1.30	1.19	1.32	1.18	1.32	2.80	2.28
1973	5.88	5.40	2.22	0.64	0.68	0.13	0.72	0.77	0.87	1.25	1.39	2.41	1.97
1974	2.03	3.05	0.78	1.01	0.98	0.79	1.34	0.95	1.30	2.01	2.83	3.76	1.76
1975	11.39	3.97	1.82	1.55	1.43	1.31	2.27	1.89	1.98	1.95	4.45	7.35	3.45
Mean	5.55	4.32	1.51	1.18	1.17	1.18	1.64	1.51	1.59	2.01	3.11	4.17	2.44

*Geometric Mean

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD, BEGIN SECTIONS HERE

SECTION 7

QUALITY ASSURANCE METHODS

Between December 1970 and December 1973, EPA quality assurance checksd primarily to validation of submitted results. The following results were limit checks that flagged data. Days not correctable were eliminated from the data file.

Limits

1.	Total air volume	vol = 1627 ± 488 m^3
2.	Tare weight	tare = $\bar{X}$ of batch ± 3s
3.	Sample weight	wt = $0 < x \leq 0.4$ g
4.	NO_3 weight	$NO_3 = 0 < x \leq 23.5\%$ TSP
5.	SO_4	$SO_4 = 0 < x \leq 37.8\%$ TSP
6.	Time	24 ± 4 hrs (1440 ± 240 min)

EPA conducted a performance audit of nitrate and sulfate analyses[11] in December 1973. As a result of this audit and a follow-up study, all sulfate data were increased by 51%. This adjustment was determined to be a laboratory bias. Accordingly, EPA sulfate results analyzed by a different laboratory are not affected. Nitrate data were not adjusted, due in part to the variability noted in reproducibility from site to site. It was concluded, however, that nitrate may also decompose on the surface of a filter, complicating retrospective chemical comparisons.

In 1974 a new contractor, Rockwell, provided chemical analyses, including TSP weighing. In November 1974, an external audit indicated that all TSP flows, the only portion audited, were within 15% of the audit result. Audits for SO_2, $SO_4^=$, and NO_3^- showed that the contractor was accurate within 5% of the EPA result. Table 7 indicates audit performance results for sulfate and nitrite during November through December of 1974. These audit results are indicative of additional audits conducted through 1975.[12]

Audits of SO_2 (spiked samples) indicated analytical accuracy within ±10%. In addition to the audit results, EPA, through the Environmental Monitoring and Support Laboratory, conducted a split-sample program. Approximately 1% of the samples were selected for the split sample program to provide real sample estimates of reproducibility and to verify the contractor's internal quality assurance program. Average results obtained for sulfate and nitrate were +1% and +4%, respectively.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.) (4-76)

TABLE 7. ROCKWELL AUDIT RESULTS, NOVEMBER 11 - DECEMBER 28, 1974

Sulfate True ($\mu g/m^3$)	% Recovery	Rel. Std. Dev.	No. Samples
2.75	93.1	3.1	24
6.49	92.3	1.5	24
17.45	94.2	0.8	24
Nitrate True ($\mu g/m^3$)	**% Recovery**	**Rel. Std. Dev.**	**No. Samples**
2.70	97.1	3.5	24
4.07	101.1	2.0	24
5.06	99.1	1.3	24

It can be seen that the contractor results were slightly higher. This may be a direct result of analysis delay. In general there was a delay of at least 60 days between sample collection and sample analysis by EPA. The contractor usually completed analyses within 2 weeks of sample collection. In addition, portions of the filters were mailed from the contractor laboratory in California to EPA in North Carolina. Both these factors could account for the slight bias observed between analytical results of the two laboratories.

Flow checks by Rockwell from 1974 through 1976 indicate that the flow usually was within 5% of the known value.

A 1977 audit by Rockwell indicated that the State of Utah uses "unconventional" hi-volume samplers. As noted earlier in the report, the sampler shelter used by Utah has a flat roof and is larger than the Federal reference method design. These factors would suggest a particle size cut-off different from EPA's sampler. The same audit indicated that the samplers were last calibrated in 1973.

Results of a 1973 EPA flow audit of twelve Utah hi-volume samplers indicated that the samplers recorded flows averaging about 20% below the EPA reference device. These results suggest that if the amount of material deposited on the filter were equal to the amounts collected by EPA samplers, the concentrations reported by Utah would be biased high by about 20%.

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE

SECTION 8

METEOROLOGICAL MEASUREMENTS

No one set of meteorological conditions is always responsible for maximum pollutant levels. For some sources, such as home heating and other short stacks, episode conditions (i.e., stable lapse rate and low winds) may be the cause of high concentrations, while for others, such as tall stack power plants, unstable lapse rates with constant average wind direction may cause a problem. Both episode frequency and unusual wind speed and direction frequency distributions have been examined to see if there have been any recent changes in the data patterns.

An air stagnation episode is defined as a period of three or more days without significant precipitation, during which the mixing height was 2000 m or less, with the average wind through the mixed layer 4 meters per second (mps) or less, or when the mixing height was 1000 m or less with the average wind 6 mps or less. These conditions correspond roughly to the stagnation index of 500 as used by the Salt Lake City office of the National Weather Service (NWS).

Mixing heights and average wind speeds used in this report were calculated by the National Climatic Center using Salt Lake City NWS surface and upper air data. The values are computed twice daily using the 12Z Rawinsonde information.

The number of episodes and the number of episode days for 1965 through 1975 have been tabulated and are given in Table 8.

In neither case can it be said that the slope is significantly different from zero; therefore, there does not seem to have been a trend in the number of stagnations, as defined above, in the period 1965-1975. Furthermore, significant changes in air quality over this period are not likely to be attributable to changes in the frequency of meteorological stagnation episodes.

Annual wind roses for 1971-1975 for the Salt Lake City airport were also obtained, and are given in Figures 7-10. Examination of these figures show a very slight, but nonetheless significant (Daniel's Test for Trend) decrease in wind from the north and north-northeast, and an equally slight increase in wind from the southeast. It is doubtful that this change, of approximately 1%, could be responsible for any major long term trends in air quality levels during 1971 to 1975.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cln.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA

TABLE 8. FREQUENCY AND DURATION OF AIR STAGNATION EPISODES, 1965-1975

Year	No. of Episodes	No. of Episode Days
1965	6	24
1966	4	21
1967	4	12.5
1968	5	27.5
1969	7	29.5
1970	4	16.5
1971	3	11.5
1972	5	16
1973	6	22.5
1974	2	11
1975	6	27.5

No trend is obvious by visual examination of the data. To refine this observation a bit, a straight line was fit through each set of data by the method of least squares. The hypothesis is that if there is a trend, either up or down, the slope of the line should be significantly different from zero.

The slope, or sample regression coefficient (b), was calculated in the standard way. The sample standard deviation from regression ($S_{y \cdot x}$) and the sample standard deviation of the regression coefficient (S_b) were calculated as follows:

$$S_{y \cdot x} = [(\Sigma y^2 - (\Sigma xy)^2/\Sigma x^2)/(n-2)]^{.5}$$

$$S_b^2 = S_{y \cdot x}^2/\Sigma x^2$$

The true slope of the line (β) is then in the interval:

$$\beta = b \pm t \cdot S_b$$

with t having n-2 degrees of freedom.

For the data given above the following were calculated:

	Episodes	Episode Days
b	- .05	- .3
$S_{y \cdot x}$	1.558	7.097
S_b	.1331	.606
$t_{.05}$	2.262	2.262
β	-.05 ± .301	-.3 ± 1.37

BOTTOM OF IMAGE AREA. OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
BEGIN LAST LINE OF TEXT HERE
3/8"

EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE

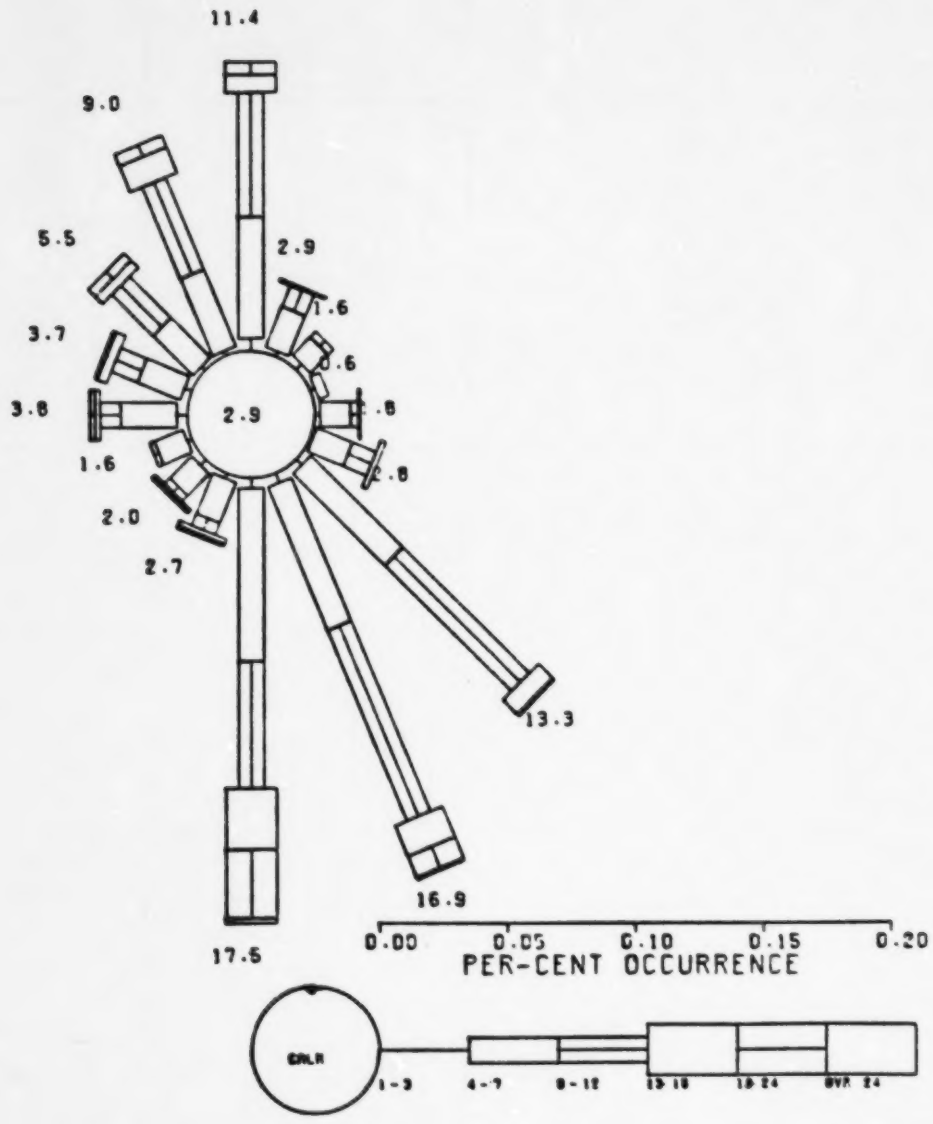

Figure 7. Salt Lake City, Utah
nicipal AP Annual Wind Rose 1972

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

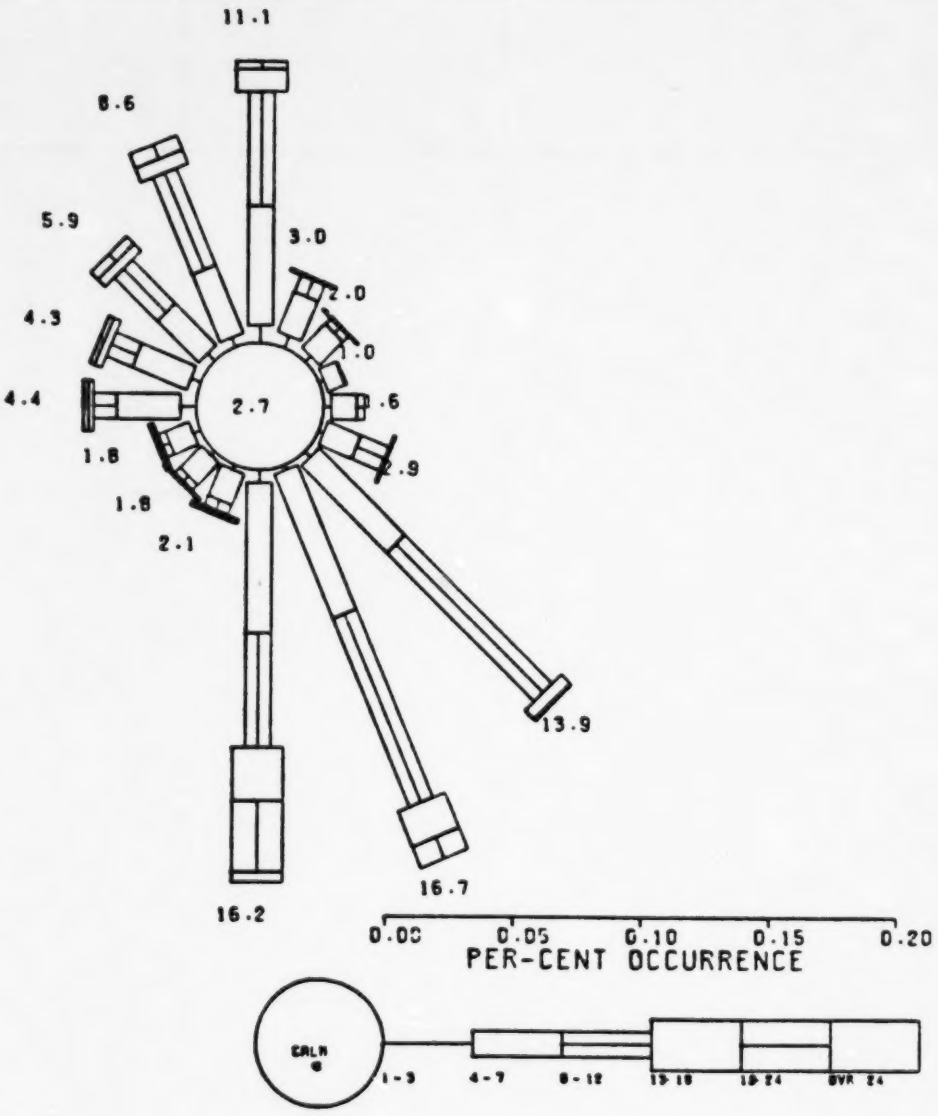

Figure 8. Salt Lake City, Utah
Municipal AP Annual Wind Rose 1973

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE

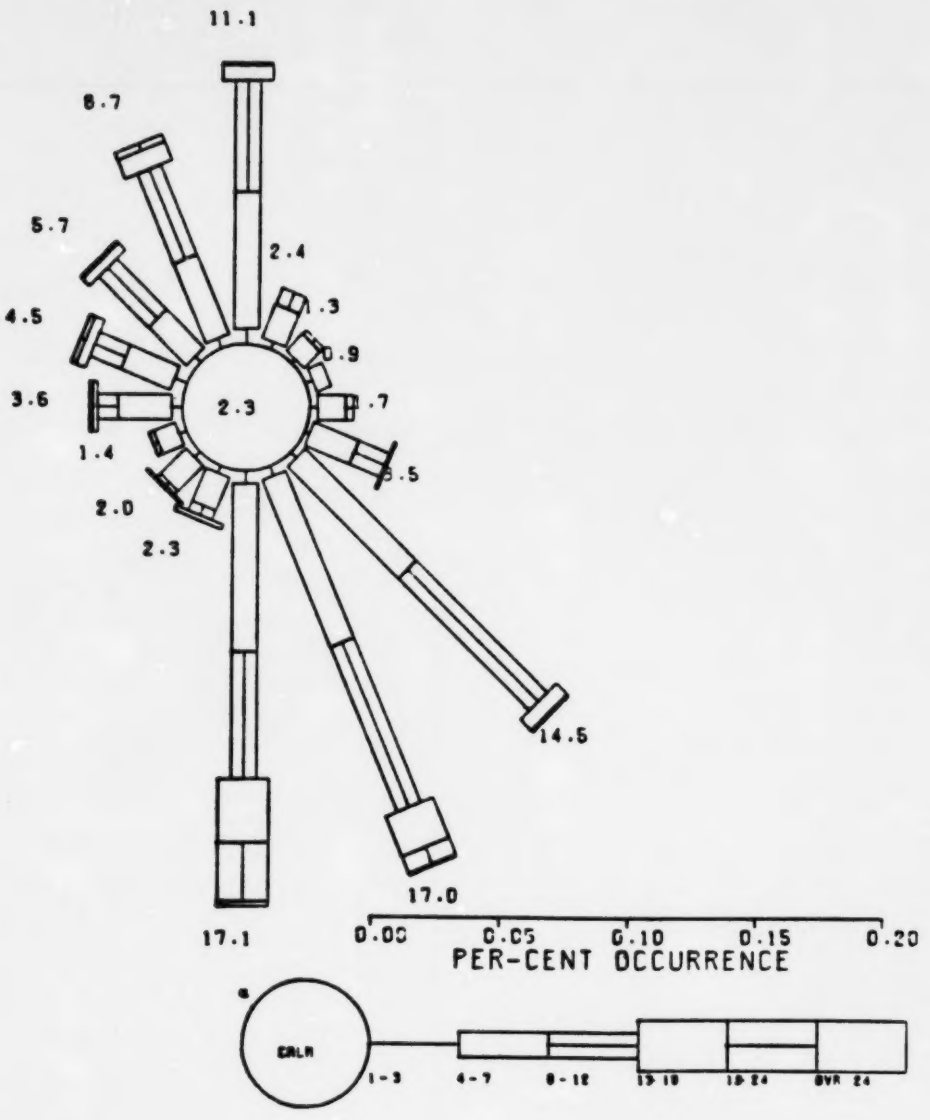

Figure 9. Salt Lake City, Utah Municipal AP Annual Wind Rose 1974

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

EPA-287 (Cin.) (4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

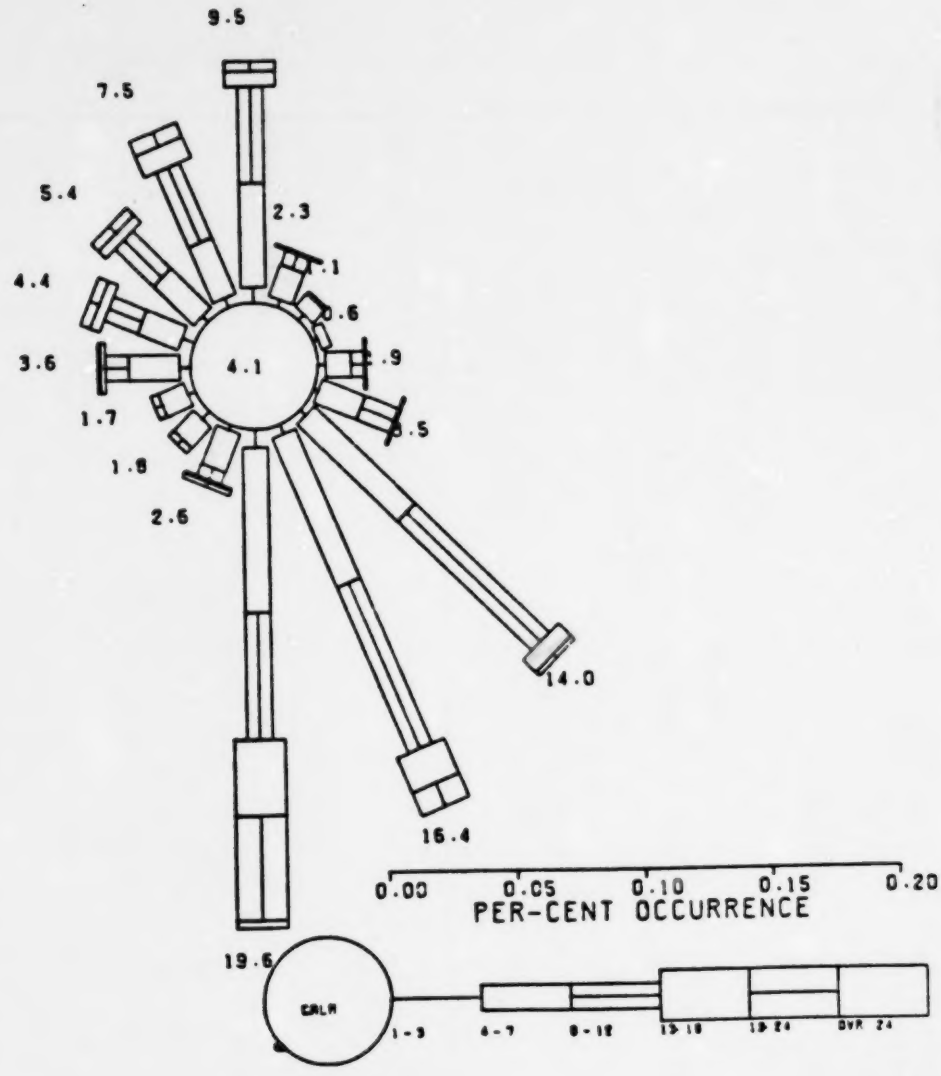

Figure 10. Salt City, Utah
Municipal AP Annual Wind Rose 1975

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

SECTION 9

EMISSION ESTIMATES

Estimates of pollutant emissions in the study area were obtained from published reports of the National Emissions Data System. A summary of these data appears in Table 9. Estimates are given for both Utah State and the Wasatch Front Air Quality Control Region, which encompass the study area. Annual data prior to 1972 are not available.

Although direct comparison of these emission estimates with air quality data is difficult at best, it does appear that ambient particulate concentrations more closely follow the pattern of area source emissions through the study period while sulfur oxide concentrations are more related to the trend in point source emissions. While no substantial changes were apparently made at the Kennecott smelter near Magna which would have significantly affected emissions from 1971 through 1975, it is understood that since that period both production and control processes have been completely renovated and updated to reduce emissions.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

EPA-287 (Cin.)
(4-76)

TABLE 9. UTAH EMISSION ESTIMATES (TONS/YEAR)

Utah State:	Particulate				Oxides of Sulfur				Oxides of Nitrogen			
Source Category	72	73	74	75	72	73	74	75	72	73	74	75
Total	79027	80580	93360	104175	168131	183007	194574	188099	89285	107592	123608	124651
Area	31390	35046	45202	31686	17958	30763	42504	34978	66038	81777	95197	89746
Point	47637	45534	48158	72489	150173	152244	152070	153121	23247	25814	28412	34905

Wasatch Front:	Particulate				Oxides of Sulfur				Oxides of Nitrogen			
Source Category	72	73	74	75	72	73	74	75	72	73	74	75
Total	57891	59994	64007	81137	154455	168279	171932	165326	57916	70743	91123	83180
Area	22905	24484	28333	22789	11745	24393	30678	30118	39184	50292	71227	62598
Point	34985	35510	35675	58348	142710	143886	141254	135207	18732	20452	19897	20582

Source:

1972 National Emissions Report EPA-450/2-74-012 USEPA, RTP, NC 27711, June 1974
1973 National Emissions Report EPA-450/2-76-007 USEPA, RTP, NC 27711, May 1976
1974 National Emissions Report EPA-450/2-78-026 USEPA, RTP, NC 27711, July 1978
1975 National Emissions Report EPA-450/2-78-020 USEPA, RTP, NC 27711, May 1978

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD, BEGIN SECTIONS HERE

SECTION 10

RESULTS AND DISCUSSION

Average ambient air pollutant concentrations measured by EPA for the entire five-year period are represented by pollutant and site in Table 10. Also included in the Table are the linear distances between the smelter and each monitoring location.

TABLE 10. SUMMARY OF FIVE-YEAR MEAN CONCENTRATIONS, $\mu g/m^3$

Site	D*	TSP**	SO_2	$SO_4^=$	NO_3^-
Magna	8	67	111	13.9	1.70
Kearns	13	47	36	7.9	2.06
Salt Lake City	21	68	18	6.9	2.67
Ogden	56	56	11	5.0	2.44

*Distance from smelter in km
**Geometric Mean Used

SPATIAL VARIATION

In the geographical area under study, the order of sites according to increasing distance from the copper smelter is as follows: Magna, Kearns, Salt Lake City, and Ogden. Examination of the mean values reported in Table 10 reveals that the same site order persists in the observed concentrations of SO_2 and $SO_4^=$ during the study period. In other words, the concentration of these pollutants appears to be a monotonic decreasing function of the distance from the smelter. Spatial variability is greatest for SO_2 concentrations, as would be expected for a primary pollutant near a large point source. The spatial patterns for TSP and NO_3^- concentrations are quite different with Salt Lake City exhibiting the highest values. This seems to indicate that population density and/or other sources are more important factors in the determination of TSP and NO_3^- concentrations than is the copper smelter.

As discussed in Section 4, the physical location of the monitoring site in each community was changed between July and September of 1972 to conform to new siting guidelines. In each case, the relocation involved a move from

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-787 (Cin.) (4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE

a one- or two-story rooftop to ground level. From Tables 3 through 6 it may be seen that while the annual mean concentrations of TSP, SO_2 and $SO_4^=$ increased from 1971 to 1972, the annual mean NO_3^- concentration decreased. This pattern is identical for each of the four communities. Since monitoring at the old and new sites did not overlap, it is not possible to separate the impact of site relocations from the year-to-year variations in pollutant concentrations.

SEASONAL VARIATION

Five-year mean concentrations are plotted by month for Magna, Kearns, Salt Lake City, and Ogden in Figures 11 through 14, respectively. Marked seasonality is observed with concentrations in the "winter" months (October through March) generally exceeding those of the "summer" months (April through September). This pattern is especially pronounced for the SO_2 measurements taken at Magna which is the site nearest the smelter. As discussed in Section 3, the persistence of winter morning inversions and low wind speeds aloft are contributing factors to the higher concentrations which are observed in the winter months.

In an effort to isolate periods of intensive pollutant buildup, the annual maximum concentration and day of occurrence are tabulated for each pollutant by site in Table 11. From this array of information, certain days and intervals of days emerge as the common occurrence of the maximum concentration for several pollutants and at several sites. Time periods so identified may be considered to be the occurrences of pollutant episodes in which the meteorological and/or emission conditions are especially conducive to the buildup of pollutant concentrations. From the table, it appears that major pollutant episodes occurred during the following periods of time:

December 18-20, 1971 (Saturday-Monday)
December 16-18, 1972 (Saturday-Monday)
January 24-25, 1973 (Wednesday-Thursday)
May 12, 1974 (Sunday)
December 9-11, 1974 (Monday-Wednesday), and
January 12-17, 1975 (Sunday-Friday).

It is interesting to note that most of these episodic events appear to impact upon the entire four-community study area. Also, consistent with the seasonal profile of monthly mean concentrations, annual maximum pollutant concentrations occurred in the "winter" period in 92.5 percent of all instances.

In checking the meteorological records from the Salt Lake City Airport for these episodic periods, it was found that all but one were characterized by low wind speeds and stable (inversion) conditions. The exception was May 12, 1974, when abnormally high winds caused blowing dust and highly elevated TSP measurements.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
6 1/2"
3/8"

PAGE NUMBER
EPA-287 (Cin.) (4-76)

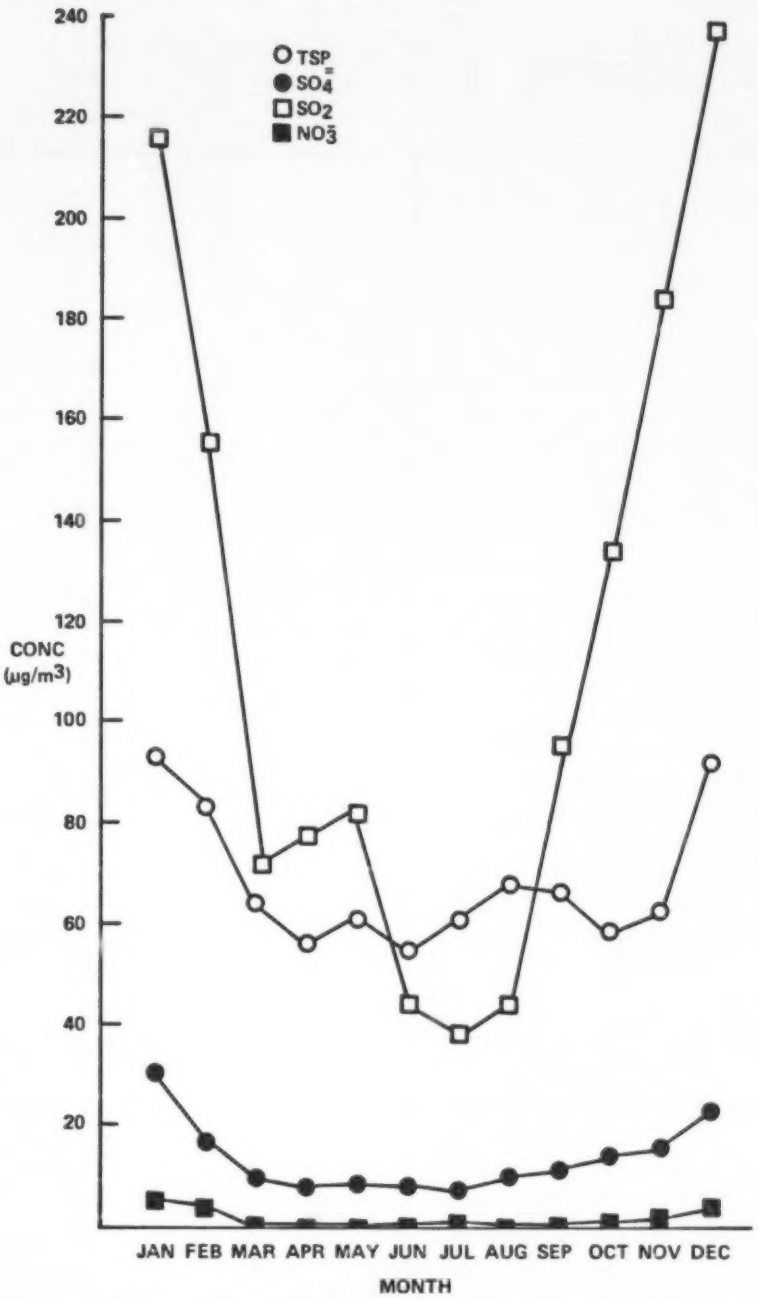

Figure 11. Five-year Mean Concentrations by Month - Magna, Utah

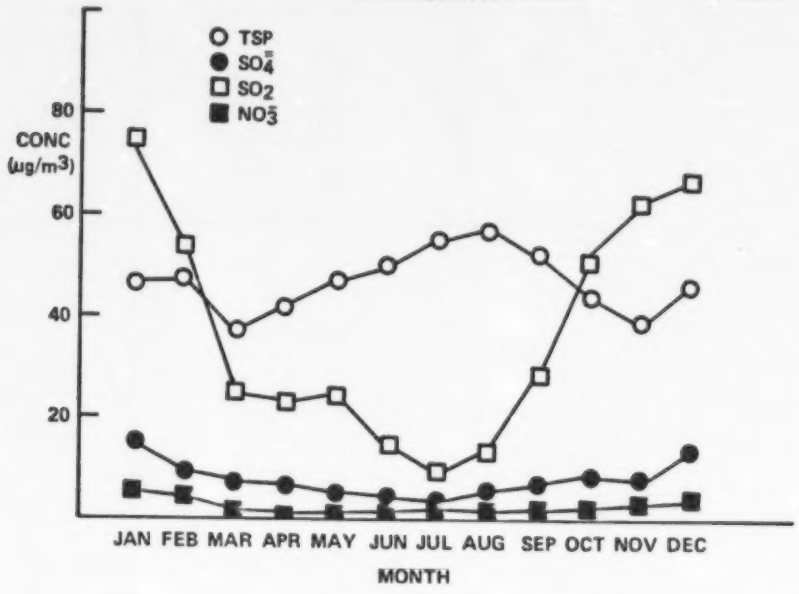

Figure 12. Five-year Mean Concentrations by Month - Kearns, Utah

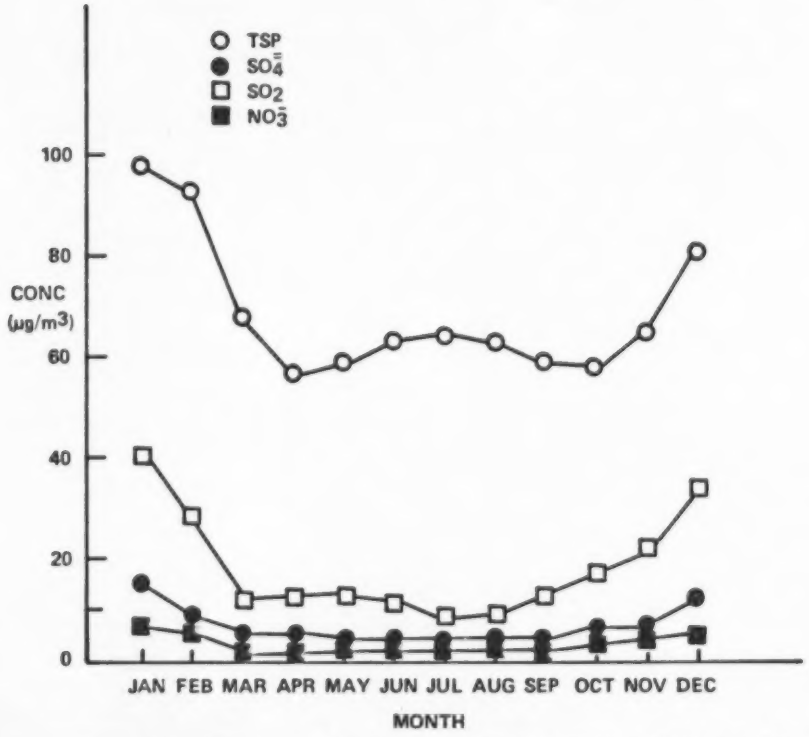

Figure 13. Five-year Mean Concentrations by Month - Salt Lake City, Utah

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD BEGIN SEC HERI

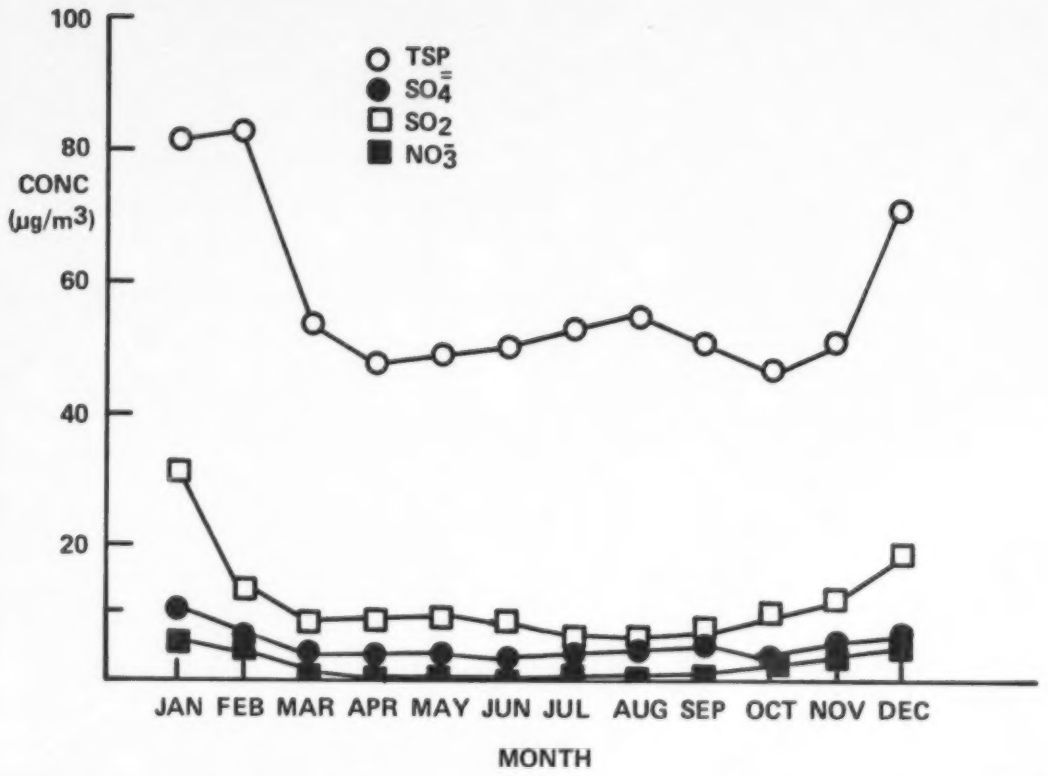

Figure 14. Five-year Mean Concentrations by Month - Ogden, Utah

BEGIN LAST LINE OF TEXT
3/8"
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
PAGE NUMBER

EPA-287 (Cin.)
(4-76)

TABLE 11. ANNUAL MAXIMUM CONCENTRATIONS (Xn), $\mu g/m^3$

Year	Site	TSP Occurrence	SO_3 Occurrence	$SO_4^=$ Occurrence	NO_3^- Occurrence
1971	Kearns	220 Sa Dec 18	358 Sa Dec 18	65.9 Su Dec 19	47.1 Su Dec 19
	Magna	482 Sa Dec 18	531 Su May 2	65.9 Th Jan 28	20.3 Sa Dec 18
	Ogden	278 We Nov 10	59 Th Apr 15	34.1 Mo Dec 20	25.1 Mo Dec 20
	Salt Lake City	332 Su Dec 19	92 Su Nov 7	54.6 Su Dec 19	34.0 Su Dec 19
1972	Kearns	228 Sa Mar 18	268 We Dec 13	85.5 Su Dec 17	37.6 Su Jan 16
	Magna	335 Mo Apr 24	1147 We Dec 13	102.3 Sa Dec 16	32.6 Tu Feb 15
	Ogden	426 Mo Dec 18	119 Su Dec 17	50.0 Su Dec 17	49.3 Mo Feb 7
	Salt Lake City	407 Mo Jan 17	201 Su Dec 17	80.9 Sa Dec 16	52.2 Mo Jan 17
1973	Kearns	295 Fr Apr 13	873 Sa Feb 3	77.8 Th Jan 25	27.1 Th Feb 1
	Magna	344 Mo Oct 22	839 Th Feb 15	96.1 Su Jan 7	10.5 Fr Dec 10
	Ogden	341 We Feb 21	195 Tu Jan 9	38.0 Th Jan 25	15.4 Fr Jan 14
	Salt Lake City	593 Th Aug 9	617 We Jan 10	77.0 Th Jan 25	18.0 We Jan 24
1974	Kearns	458 Su May 12	384 Fr Oct 18	55.7 Mo Dec 9	18.0 Tu Dec 10
	Magna	623 Su May 12	995 Mo Dec 9	110.9 Mo Dec 9	26.7 Th Feb 12
	Ogden	424 Su May 12	113 Su Jan 27	16.8 We Dec 11	11.7 Tu Dec 10
	Salt Lake City	652 Su May 12	88 Mo Feb 11	53.4 We Jan 9	16.5 Tu Dec 10
1975	Kearns	257 Tu Oct 7	623 Mo Dec 22	69.2 Th Jan 16	30.1 We Jan 15
	Magna	689 Fr Jan 17	964 Su Jan 12	293.5 Th Jan 16	49.1 Fr Jan 17
	Ogden	241 We Jan 15	325 Su Jan 12	46.5 Th Jan 16	47.6 We Jan 15
	Salt Lake City	223 Th Jan 16	93 Tu Jan 14	47.5 Mo Jan 22	29.0 Tu Jan 6

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

LONG-TERM TRENDS

Figures 15 through 18 depict the annual mean concentrations at the four sites for TSP, SO_2, $SO_4^=$, and NO_3^-, respectively. For TSP concentrations, Magna and Kearns (circles) seem to exhibit similar trend patterns over the five-year period while a somewhat different profile is evidenced at both Ogden and Salt Lake City boxes. This suggests the possibility that the smaller and more frequently downwind communities of Magna and Kearns are impacted primarily by a common source (i.e., the cooper smelter) which is of lesser importance in the more distant and larger cities of Salt Lake and Ogden.

Trend patterns for SO_2, $SO_4^=$, and NO_3^- are similar among the four communities. Most notable is the monotonically increasing SO_2 trend in Magna where the mean concentration more than doubled from beginning to end of the study period. In contrast, NO_3 concentrations were uniformly low and apparently stable throughout the geographical area and time period.

To assess the apparent trends in a more quantitative manner, mean pollutant concentrations were computed for the following intervals: 1971-1973 and 1973-1975. By including 1973 in the computation of both three-year means, the study period is effectively divided into two balanced intervals. The percentage change in concentration of the latter to the former interval was computed for each pollutant and site, and the results appear in Table 12. This table suggests that all pollutants increased in concentration at the Magna site while all pollutants decreased in concentration at Salt Lake City. The largest quantitative changes were the increased SO_2 levels at Magna and Kearns and the decrease in TSP concentration at Ogden.

TABLE 12. PERCENTAGE CHANGE IN CONCENTRATION
1973-1975 AVERAGE vs. 1971-1973 AVERAGE

SITE	TSP**	SO_2	$SO_4^=$	NO_3^-
Kearns	+ 2.1	+34.4	-10.3	+ 2.6
Magna	+12.3	+51.6	+ 5.0	+10.7
Ogden	-25.8	+ 9.1	-21.1	+ 2.2
Salt Lake City	-16.0	- 5.0	-20.3	- 4.6

Daniel's Test for trend[10] makes use of the Spearman Rank correlation coefficient to determine whether an apparent trend has statistical significance. This statistic was computed for each time series within the Utah data base and the results are shown in Table 13. According to this criterion, the large increases in SO_2 levels noted at the Magna and Kearns sites along with the decrease in TSP concentration at Ogden are all probably real. In

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"

PAGE NUMBER
EPA-287 (Cin.)
(4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTION HERE

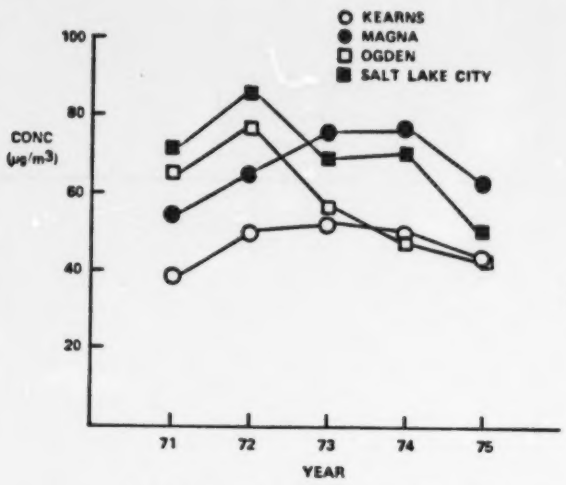

Figure 15. Annual Mean* Concentrations - TSP

*Geometric Mean Used

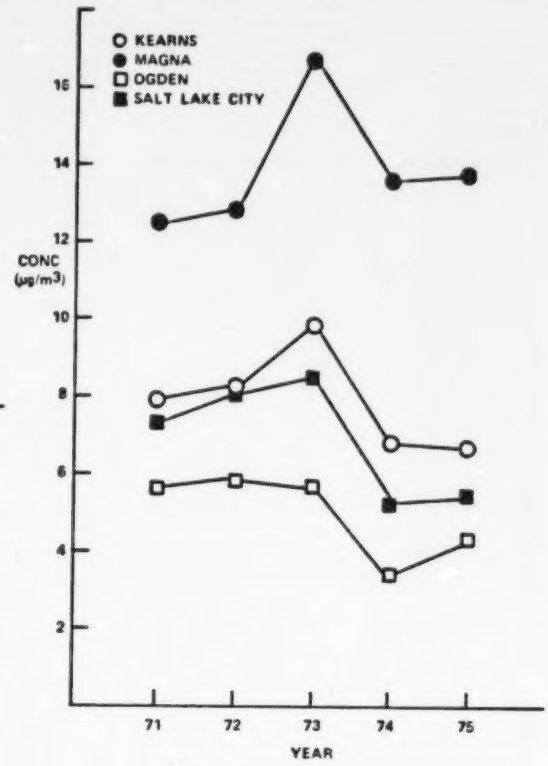

Figure 17. Annual Mean Concentrations-$SO_4^=$

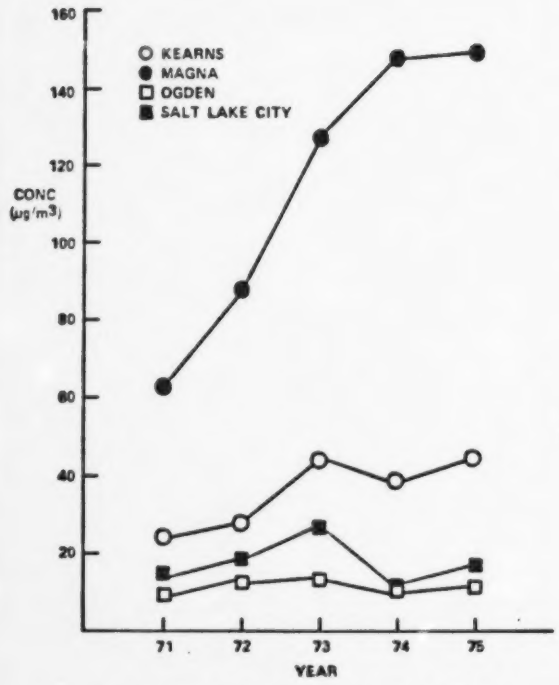

Figure 16. Annual Mean Concentrations - SO_2

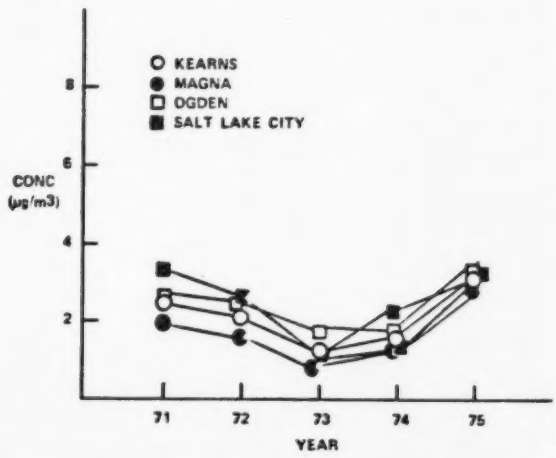

Figure 18. Annual Mean Concentrations - NO_3^-

BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
BEGIN LAST LINE OF TEXT
3/8"

PAGE NUMBER
EPA-287 (Cin.) (4-76)

addition, a 5 percent increase in SO_4 concentration at Magna and a 16 percent decline in TSP concentration at Salt Lake City also pass this test of statistical significance.

TABLE 13. SPEARMAN RANK CORRELATION COEFFICIENTS
DANIEL'S TEST FOR TREND

SITE	TSP**	SO_2	$SO_4^=$	NO_3^-
Kearns	+ .25	+ .70*	- .60	+ .10
Magna	+ .30	+1.00*	+ .70*	+ .10
Ogden	- .90*	+ .30	- .60	0
Salt Lake City	- .80*	- .35	- .50	- .30

*Statistically Significant Trend @ P = 0.90.
**Geometric Mean Used

COMPARISON OF USEPA AND USDH MEASUREMENTS

As previously mentioned, the Utah State Division of Health operated air monitoring sites in each of the four communities of interest throughout the study period. A comparison of USDH with EPA data for TSP and SO_2 appears in Table 14. A paired t-test reveals that a statistically significant bias exists in the TSP data with the USDH measurements consistently exceeding those from EPA. The paired TSP data are correlated with a coefficient of 0.68. A much better interlaboratory agreement exists for SO_2 where the data are correlated with a coefficient of 0.95 and show a statistically insignificant bias.

As pointed out in Sections 5 and 7, the collection method used by USDH for particulate material differed considerably from the EPA Reference Method, so the lack of interagency agreement in these measurements is not totally unexpected.

TABLE 14. COMPARISON OF DATA FROM USEPA AND USDH ($\mu g/m^3$)

		TSP		SO_2	
Community	Year	EPA	USDH	EPA	USDH
Kearns	1971	39	51	23	34
	1972	50	54	28	26
	1973	51	54	45	47
	1974	50	58	39	-
	1975	44	51	44	52
Magna	1971	54	71	62	107
	1972	65	70	86	90
	1973	77	75	117	126
	1974	79	84	143	118
	1975	63	73	149	123
Ogden	1971	66	78	9	11
	1972	77	87	12	21
	1973	56	77	13	8
	1974	47	83	10	5
	1975	43	81	12	21
Salt Lake City	1971	71	94	15	21
	1972	86	94	18	11
	1973	68	89	27	18
	1974	70	93	12	16
	1975	50	82	17	13
		df = 19 t = -5.78 P(t)<.001		df = 18 t = -0.12 P(t) = .906	

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE

REFERENCES

1. Health Consequences of Sulfur Oxides: A report from CHESS, 1970-1971. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EPA-650/1-74-004. 1974.

2. Shy, C.M., Riggan, W.B., French, J.G., Nelson, W.C., Dickerson, R.C., Benson, F.B., Finklea, J.F., Colucci, A.V., Hammer, D.I., and Newill, V.A. An Overview of CHESS. Ibid.

3. CHESS Measurement Methods, Precision of Measurements, and Quality Control. Ibid.

4. West, P.W. and Gaeke, G.C. Fixation of Sulfur Dioxide as Sulfitomercurate III and Subsequent Colorimetric Determination. Anal. Chem. 28:1816-1819, 1956.

5. Scaringelli, F.P., Saltzman, B.E., and Frey, S.A., Spectrophotometric Determination of Atmospheric Sulfur Dioxide. Anal. Chem. 39;1709-1719, December 1967.

6. U.S. Environmental Protection Agency, National Primary and Secondary Ambient Air Quality Standards; Reference Method for the Determination of Sulfur Dioxide in the Atmosphere (Pararosaniline Method). Title 40, Code of Federal Regulations, Part 50, Appendix A.

7. U. S. Environmental Protection Agency. National Primary and Secondary Ambient Air Quality Standards; Reference Method for Determination of Suspended Particulates in the Atmosphere (High Volume Method). Title 40, Code of Federal Regulations, Part 50, Appendix B.

8. McKee, H.C., Childers, R.E., and Saenz, O. Collaborative Study of Reference Method for the Determination of Suspended Particulates in the Atmosphere (High Volume Method). Southwest Research Institute, San Antonio, Texas. Contract CPA 70-40, SWRI Project 21-2811. June 1971.

9. Air Quality Criteria for Sulfur Oxides. National Air Pollution Control Administration, Public Health Service, U.S. Department of Health, Education, and Welfare, Durham, N.C. NAPCA Publication No. AP-50, January 1969.

10. Guidelines for the Evaluation of Air Quality Trends. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, N.C. OAQPS, No 1-2-014, February 1974.

BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA, OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
6-1/2"
3/8"

PAGE NUMBER
EPA-287 (Cin.) (4-76)

BEGIN FIRST LINE OF TEXT HERE
TYPING GUIDE SHEET
CENTER OF PAGE
TOP OF IMAGE AREA
DROPPED HEAD: BEGIN SECTIONS HERE
6-1/2"
9-1/8"
BEGIN LAST LINE OF TEXT
BOTTOM OF IMAGE AREA; OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
3/8"
PAGE NUMBER
EPA-287 (Cin.)
(4-76)

11. Heidersheit, L.T. and Hertz, M.B. An Assessment of the CHESS Sulfate and Nitrate Data During the Period RETA Performed the Chemical Analysis. EPA-600/1-77-004, January 1977.

12. Puzak, J.C. and Clark, T. External Laboratory Quality Assurance for the Los Angeles Catalyst Study. EPA 600/4-77-034. June 1977.

13. Rockwell International. Evaluation of State of Utah Air Monitoring Activity. Contract Report to USEPA (68-02-2412). March 1977.